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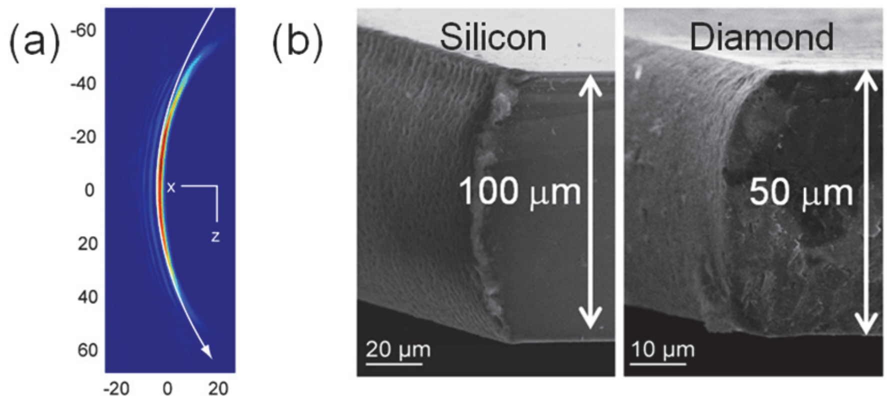
Although versatile and widely used, femtosecond laser micro-nanomachining faces a challenge for the fabrication of high aspect ratio or deep structures. The control of the profile along the longitudinal dimension is extremely difficult. In this context, our approach is based on controlling the direction of light rather than shaping the intensity pattern in one plane. Here we review our recent work in this field using Bessel beams and accelerating beams.

In Bessel beams, light propagates along the generatrix of a cone, with a fixed radial wavevector. Contrary to Gaussian beams, the femtosecond filamentation regime of Bessel beams can be stationary, and can generate extended plasma tracks in dielectrics. This allowed us to generate nanochannels in glass with aspect ratio up to 100:1 [1]. Numerical simulations of the nonlinear propagation in this regime show the importance of the conical structure in generating extremely dense plasmas [2].

Airy beams and more generally accelerating beams constitute another family of beams that possess quasi-nondiffracting behaviour and their nonlinear propagation can also be stationary. Their primary intensity lobe propagates along a curved trajectory that can be arbitrarily shaped even in the nonparaxial regime. Since this lobe is adjacent to a region where no light propagates, accelerating beams can be used for direct curved edge profiling and trench processing in transparent and opaque materials [3,4].

Our results show that controlling the linear and nonlinear propagation of ultrashort femtosecond laser pulses by nondiffracting beams is a key new technological approach for laser processing.



(a) Intensity distribution of a circularly accelerating beam. (b) Edge profiling on silicon and diamond.

References

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